ORIGINAL RESEARCH

Chapter 4: Effective Search Strategies for Systematic Reviews of Medical Tests

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This article discusses techniques that are appropriate when developing search strategies for systematic reviews of medical tests. This includes general advice for searching for systematic reviews and issues specific to systematic reviews of medical tests. Diagnostic search filters are currently not sufficiently developed for use when searching for systematic reviews. Instead, authors should construct a highly sensitive search strategy that uses both controlled vocabulary and text words. A comprehensive search should include multiple databases and sources of grey literature. A list of subject-specific databases is included in this article.

KEY WORDS: systematic reviews; bibliographic databases; information retrieval.
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Locating all published studies relevant to the key questions is a goal of all systematic reviews. Inevitably, systematic reviewers encounter variation in whether or how a study is published and in how the elements of a study are reported in the literature or indexed by organizations such as the National Library of Medicine. A systematic search must attempt to overcome these issues in order to identify all relevant studies, taking into account the usual constraints on time and resources.

Although I have written this article to serve as guidance for Evidence-based Practice Centers (EPCs), I also intend for this to be a useful resource for other investigators interested in conducting systematic reviews on medical tests; in particular this provides guidance for the librarian or information specialist conducting the search. Searching for genetic tests and prognostic studies is covered in papers 11 and 12 of this series.

While this paper will discuss issues specific to systematic reviews of medical tests (screening, diagnostic and prognostic), it is important to remember that general guidance on searching for systematic reviews[1] also applies. Literature searches will always be a balance between recall (how much of the relevant literature is located) and precision (how much of the retrieved literature is relevant). The optimal balance depends on context. Within the context of comparative effectiveness research, the goal is to have a comprehensive (if not exhaustive) search while still trying to minimize the resources necessary for review of the retrieved citations.

In general, bibliographic searches should always include MEDLINE and the Cochrane Central Register of Controlled Trials. Additional databases that are often useful to search include EMBASE, CINAHL and PsychINFO. When constructing the searches in these bibliographic databases, it is important to use both controlled and uncontrolled vocabulary and to tailor the search for each individual database. Limits such as age and language should not be used unless a specific case can be made for their use.

Working closely with the research team as well as the analytic framework and inclusion and exclusion criteria will help to develop the search strategy. Reading the references of all included studies is a useful technique to identify additional studies, as is using a citation database such as Scopus or Web of Science to find articles that have cited key articles. In addition to published literature, a comprehensive search will include looking for unpublished or "grey literature." In the context of comparative effectiveness research regulatory information, clinical trial registries and conference proceedings/abstracts are the most useful sources for identifying data.

COMMON CHALLENGES

Systematic reviews of test strategies for a given condition require a search on each of the relevant test strategies under consideration. In conducting the search, systematic reviewers may use one of two approaches. The reviewers may search on all possible tests used to evaluate the given disease, which requires knowing all the possible test strategies available, or they may search on the disease or condition and then focus on medical test evaluation for that disease.

When a review focuses on specific named tests, searching is relatively straightforward. The names of the tests can be used to locate studies, and a specific search for the

concept of diagnosis, screening or prognosis may not be necessary[2,3]. Because testing strategies are constantly evolving, using the strategy of relying on specific named tests may risk missing emerging approaches. Tests that measure a gene product may be associated with multiple diseases, so searching by test name alone may be insufficient. Searching for the target illness in addition to known test names, or alone if specific tests are unknown, is often advisable. However, searches for a disease or condition are broader searches and greatly increase the burden of work in filtering down to the relevant studies on medical test evaluation.

PRINCIPLES FOR ADDRESSING THE CHALLENGES

Principle 1: Do Not Rely on Search Filters Alone

Several search filters (sometimes called "hedges"), which are pre-prepared and tested searches that can be combined with searches on a particular disease or condition, have been developed to aid systematic reviewers evaluating medical tests. Most of these filters have been developed for MEDLINE®[2–6]. In particular, one filter[7] is used in the PubMed® Clinical Queries for diagnosis (Table 1). Search filters have also been developed specifically for diagnostic imaging[8] and for EMBASE®[9,10].

Unfortunately, although these search filters are useful for the casual searcher who simply needs some good articles on diagnosis, they are inappropriate for use in systematic reviews of clinical effectiveness. Several researchers[6,11–14] have reported that using these filters for systematic reviews may result in relevant studies being missed. Vincent found that most of the available filters perform better when they are being evaluated than when they are used in the context of an actual systematic review[13]; this finding is particularly true for studies published before 1990 because of non-standardized reporting and indexing of medical test studies.

In recent years, improved reporting and indexing of randomized controlled trials (RCTs) have made such trials much easier to find. There is reason to believe that reporting and indexing of medical test studies will similarly improve in the future[12]. In fact, Kastner and colleagues[15] recently reviewed 22 systematic reviews of diagnostic accuracy published in 2006 to determine whether the PubMed Clinical Queries Filter for diagnosis would be sufficient to locate all the primary studies that the 22 systematic reviews had identified through traditional search strategies. Using these filters in MEDLINE and EMBASE, the authors found 99 percent of the articles in the systematic reviews they examined, and they determined that the missed articles would not have altered the conclusions of the systematic reviews. The authors therefore concluded that filters may be appropriate when searching for systematic reviews of medical test accuracy. However, until more evidence of their effectiveness is found, we recommend that searchers not rely on them exclusively.

Principle 2: Do Not Rely On Controlled Vocabulary (Subject Headings) Alone

It is important to use all known variants of the test name such as abbreviations, generic and proprietary names as well as international terms and spellings, when searching, and these may not all be controlled vocabulary terms. Because reporting and indexing of studies of medical tests is so variable, one cannot rely on controlled vocabulary terms alone[3].

Using textwords for particular medical tests will help to identify medical test articles that have not yet been indexed or that have not been indexed properly[2]. Filters may suggest the sort of textwords that may be appropriate. Michel[16] discusses appropriate MeSH headings and other terminology useful for searching for medical tests.

Principle 3: Search in Multiple Locations

As always—but in particular with searches for studies of medical tests—we advise systematic reviewers to search more than one database and to tailor search strategies to each individual database[17]. Because there can be little overlap between many databases[18–20], failure to search additional databases carries a risk of bias[21–23]. For more information on potentially appropriate databases to use, see Table 2.

Until reporting and indexing are improved and standardized, a combination of highly sensitive searches and brute force article screening will remain the best approach for systematically searching the medical test literature[6,11–13]. However, this approach is still likely to miss relevant articles; therfore, authors should search additional sources of information. Citation tracking, the reading of references of relevant articles as well as identifying articles that cite key studies, is an important sources of additional citations[24]. Table 3 lists databases that are appropriate for tracking citations.

Table 1. Diagnosis Clinical Query for PubMed

Category	Optimization	Sensitivity/ specificity	PubMed search string
Diagnosis	Sensitivity/ breadth	98%/74%	(sensitiv*[Title/Abstract] OR sensitivity and specificity[MeSH Terms] OR diagnos*[Title/Abstract] OR diagnosis[MeSH:noexp] OR diagnostic* [MeSH:noexp] OR diagnosis,differential[MeSH:noexp] OR diagnosis[Subheading:noexp])
	Specificity/ narrowness	64%/98%	(specificity[Title/Abstract])

Table 2. Specalized Databases

Free databases		
Database	**URL**	**Topic coverage**
C2-SPECTR (Campbell Collaboration's Social, Psychological, Educational and Criminology Trials Register)	http://geb9101.gse.upenn.edu	Trial Register for Social Sciences (similar to DARE)
ERIC (Education Resources Information Center)	http://www.eric.ed.gov	Education, including the education of health care professionals as well as educational interventions for patients
IBIDS (International Bibliographic Information on Dietary Supplements)	http://ods.od.nih.gov/Health_Information/IBIDS.aspx	Dietary supplements
ICL (Index to Chiropractic Literature)	http://www.chiroindex.org	Chiropractic
NAPS (new Abstracts and Papers in Sleep)	http://www.websciences.org/bibliosleep/naps/default.html	Sleep
OTseeker (Occupational Therapy Systematic Evaluation of Evidence)	http://www.otseeker.com	Occupational therapy
PEDRo (Physiothrarpy Evidence Database)	http://www.pedro.org.au/	Physical therapy
PILOTS	http://www.ptsd.va.gov/ptsd_adv_search.asp	PTSD ad traumatic stress
PopLine	http://www.popline.org	Population, family planning and reproductive health
PubMed	http://www.ncbi.nlm.nih.gov/pubmed	Biology and health sciences
RDRB (Research and Development Resource Base)	http://www.rdrb.utoronto.ca/about.php	Medical education
RehabData	http://www.naric.com/research/rehab	Rehabilitation
Social Care Online	http://www.scie-socialcareonline.org.uk	Social care including: healthcare, social work and mental health
TOXNET	http://toxnet.nlm.nih.gov	Toxicology, environmental health, adverse effects
TRIS (Transportation Research Information Service)	http://ntlsearch.bts.gov/tris/index.do	Transportation research
WHO Global Health Library	http://www.who.int/ghl/medicus/en/	International biomedical topics. Global Index Medicus
Subscription databases		
AgeLine	http://www.csa.com/factsheets/ageline-set-c.php	Aging, health topics of interest to people over 50
AMED (Allied and Complimentary Medicine Database)	http://www.ovid.com/site/catalog/DataBase/12.jsp	Complementary medicine and allied health
ASSIA (Applied Social Science Index and Abstracts)	http://www.csa.com/factsheets/assia-set-c.php	Applied social sciences including: anxiety disorders, geriatrics, health, nursing, social work and substance abuse
BNI (British Nursing Index)	http://www.bniplus.co.uk/about_bni.html	Nursing and midwifery
ChildData	http://www.childdata.org.uk/	Child-related topics including child health
CINAHL (Cumulative Index to Nursing and Allied Health)	http://www.ebscohost.com/cinahl	Nursing and allied health
CommunityWISE	http://www.oxmill.com/communitywise/	Community issues including community health
EMBASE	http://www.embase.com	Biomedical with and emphases on drugs and pharmaceuticals, more non-US coverage than MEDLINE
EMCare	http://www.elsevier.com/wps/find/bibliographicdatabasedescription.cws_home/708272/description#description	Nursing and allied health
Global Health	http://www.cabi.org/datapage.asp?iDocID=169	International health
HaPI (Health and Psychosocial Instruments)	http://www.ovid.com/site/catalog/DataBase/866.jsp	Health and psychosocial testing instruments
IPA (international Pharmaceutical Abstracts)	http://www.csa.com/factsheets/ipa-set-c.php	Drugs and pharmaceuticals
MANTIS (Manual Alternative and Natural Therapy Index System)	http://www.healthindex.com/MANTIS.aspx	Ostopathy, chiropractic and alternative medicine
PsycINFO	http://www.apa.org/pubs/databases/psycinfo/index.aspx	Psychological literature
Sociological Abstracts	http://www.csa.com/factsheets/socioabs-set-c.php	Sociology including: health and medicine and the law, social psychology and substance abuse and addiciton
Social Services Abstracts	http://www.csa.com/factsheets/ssa-set-c.php	Social services including: mental health services, gerontology and health policy

In addition to bibliographic databases and citation analysis, regulatory documents are another potential source of information for systematic reviews of medical reviews. The FDA regulates many medical tests as devices. The regulatory documents for diagnostic tests are available on the FDA's Device website: http://www.accessdata.fda.gov/scripts/cdrh/devicesatfda/index.cfm.

Illustration

As an example, in the AHRQ report, *Testing for BNP and NT-proBNP in the Diagnosis and Prognosis of Heart Failure*,[25] the medical tests in question were known. Therefore, the search consisted of all possible variations on the names of these tests and did not need to include a

Table 3. Citation Tracking Databases

Database	URL	Subscription status
Google Scholar	http://scholar.google.com	Free
PubFocus	http://pubfocus.com	Free
PubReMiner	http://bioinfo.amc.uva.nl/human-genetics/pubreminer	Free
Scopus	http://info.scopus.com	Subscription required
Web of Science	http://thomsonreuters.com/products_services/science/science_products/a-z/web_of_science	Subscription required

search string to capture the diagnostic testing concept. By contrast, in the AHRQ report, *Effectiveness of Noninvasive Diagnostic Tests for Breast Abnormalities*,[26] all possible diagnostic tests were not known. For this reason, the search strategy included a search string meant to capture the diagnostic testing concept, and this relied heavily on textwords. The actual search strategy used in PubMed to capture the concept of diagnostic tests was as follows: diagnosis OR diagnose OR diagnostic OR di[sh] OR "gold standard" OR "ROC" OR "receiver operating characteristic" OR sensitivity and specificity[mh] OR likelihood OR "false positive" OR "false negative" OR "true positive" OR "true negative" OR "predictive value" OR accuracy OR precision.

SUMMARY

Key points are:

- Diagnostic search filters—or, more specifically, the reporting and indexing of medical test studies upon which these filters rely—are not sufficiently well developed to be depended upon exclusively for systematic reviews.
- If the full range of tests is known, one may not need to search for the concept of diagnostic testing; searching for the specific test using all possible variant names may be sufficient.
- Combining highly sensitive searches utilizing textwords with hand searching and acquisition and review of cited references in relevant papers is currently the best way to identify all or most relevant studies for a systematic review.
- Do not rely on controlled vocabulary alone.
- Check Devices@FDA.

Conflict of Interest: *The author declares that he/she does not have a conflict of interest.*

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